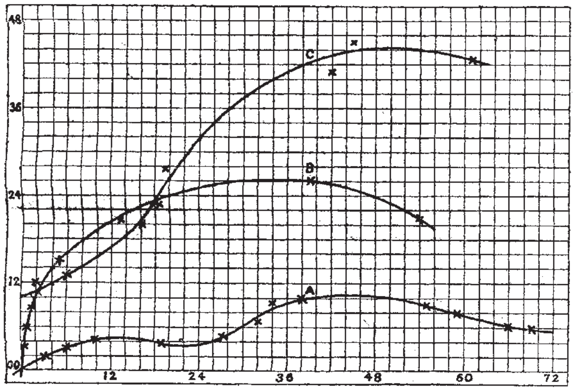
preparation was not a sufficient guarantee of the purity it was established either by analysis or by the determination of its vapour density—a most rigid test, provided that this could be ascertained with sufficient accuracy. I have ventured to modify the original form of the Gay-Lussac-Hofmann apparatus, and I think I may claim that this modification admits of all the precision which the process is capable of yielding. It obviates some of the disadvantages of the original method, such as the liability to crack the tube, and the use of a large quantity of mercury and of liquid to vaporise the body under investigation, and it also permits of a more certain application of the necessary corrections.

Among the many problems suggested by a review of our present knowledge of the subject, the following seemed to me to be specially worthy of solution.

I. Is it definitely established that an element in combination has as a rule an invariable specific volume? May not the volume be modified by the number of the atoms of that particular element in the molecule? Is it altogether independent of the general complexity of the molecule, or may not the specific volume of the molecule be a function of its weight?



Curves showing rise of fixed points in thermometers.

II. Do the various members of a family of elements possess identical specific volumes, or may not the volume be a function of the atomic weight?

III. Would a re-examination of the cases of so-called variable atomic value serve to show that the specific volume of an element is a function of that value, as Buff supposes?

IV. The hypotheses of Mendelejeff and Meyer indicate the need of additional and more exact determinations of the values for the specific volumes of the elementary bodies?

This scheme of work required the determination of the specific gravities, boiling-points, and thermal expansions of about fifty liquids, and the results of the observations afford material for the calculation of the specific volumes of seventeen elementary bodies. The rates of expansion are represented by formulæ of the form—

$$V = A + Bt + Ct^2 + Dt^3.$$

The labour of reducing the observations, and more especially of calculating the empirical formulæ for so large a number of substances, has been materially lightened by the use of the arithmometer of Thomas (de Colmar). The investigation has therefore incidentally added very considerably to the data upon which the determination of the general laws affecting the thermal expansion of liquid bodies must depend.

After a discussion of the errors of the observations and a comparison of my results with those obtained by previous observers, whenever these were applicable, I have summarised the main conclusions to which I have been led as follows:—

1. It seems certain that many isomeric liquids, even of the same chemical type (using that phrase in the sense in which it is employed by Kopp) have not identical specific gravities at their respective boiling-points, and hence have not identical specific volumes. Such exceptions are more commonly met with in compounds containing carbon and hydrogen; this fact appears to indicate that the specific volume of one or both of these elements is not absolutely invariable. Benzene derivatives especially show a greater departure from the general law than can be fairly attributed to experimental error. Their variations are of the same order as has been shown to occur in the refraction values for these compounds.

2. We must also suppose that of the additional elements, oxygen, sulphur, and nitrogen have likewise variable specific volumes in conformity with Kopp's conclusions.

3. There is at present no experimental evidence for assuming that any other element has a variable specific volume.

4. Hence in the case of these elements the volume is not modified by the number of the atoms of the particular element in the molecule, and it is therefore altogether independent of the general complexity of the molecule.

5. The different members of a family of elements do not possess identical specific volumes; the volumes of the elements are periodic functions of their atomic weights.

6. The inquiry affords no evidence in support of the hypothesis that the specific volume of an element in combination is modified by any possible variation in the affinity value which it may possess. T. E. THORPE

GORDON'S "ELECTRICITY AND MAGNETISM"

A Physical Treatise on Electricity and Magnetism. By J. E. H. Gordon. (London: Sampson Low and Co., 1880.)

THE author, in the first paragraph of his preface, draws a distinction between the physical and mathematical points of view in treating the Science of Electricity. Unfortunately, the distinction is at present a real one. Many mathematicians, fascinated by the beauty of the instruments they handle, are disposed to treat physical problems as though the principal function of the universe were to suggest problems to the pure mathematician, instead of the principal function of the pure mathematician being to provide suitable tools for solving physical problems. On the other hand, there are skilful experimentalists who fail to appreciate those powerful methods of deductive quantitative reasoning which they are themselves unable to handle. Mr. Gordon does not profess to be a mathematician, and adopts the experimental point of view.

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The book makes no claim to be a complete treatise, but rather to deal with those branches of the science with which the author is best acquainted, one might almost say, those parts at which he has himself worked, either originally or by way of verifying the work of others. As might be expected from such a scheme, the descriptions of apparatus and phenomena are admirable, but, unfortunately, the theoretical explanations, intended to give the book more or less the character of a systematic treatise, are neither clear nor accurate. So early as page 2 we read: "It is found that if equal quantities of the electricity of glass and the electricity of sealing-wax be added together they neutralise each other." But this is not preceded by any explanation of what is meant by equal quantities of the electricities of glass and sealing-wax. If the sentence had been cast as a definition, it would have been comprehensible. On page 20 there is an extraordinary illustration of the medium supposed to transmit electrostatic forces:—

> "The transmission of strain may be very beautifully seen at any railway-station when shunting is going on, if a train of carriages is being pushed by an engine which happens, instead of giving a steady pressure, to strike a slight blow on the carriage nearest to it. The furthest carriage does not move at once, but the buffer springs are compressed—that is, the first carriage is for an instant strained by having its total length shortened by some inches. It instantly recovers from this strain by the expansion of the springs; but as it cannot expand towards the engine, it expands away from it, and transmits the strain to the next carriage by compressing its buffer-springs, and the process is repeated all the way from the engine to the carriage furthest from it."

This buffer experiment is an illustration of wave-motion, an idea we do not need in any theory of electrostatics. On page 23 there is a popular explanation from the pen of Prof. Ayrton of the easy discharge of electricity from points; this remarkable explanation does not in any way depend on the greater electric surface density at and near a point, and it suggests that the force near a conductor is *not* normal to its surface. It is unnecessary to pursue this criticism further; we have said enough to show that Mr. Gordon's strength does not lie in the systematic exposition of electrical theory.

The book is divided into four parts—Electrostatics, Magnetism, Electrokinetics, and Electro-optics. In the third part is included all the phenomena of current electricity. This is an unsatisfactory classification. Electrokinetics should be confined to those phenomena of current electricity which involve the kinetic energy of current, such as electromagnetism and electromagnetic induction. The author would have been wiser to have followed the arrangement of Maxwell, and have classed the steady flow of electricity in conductors at rest rather with electrostatics than electrokinetics. Adams's experiments on equipotential lines and surfaces in conductors are interpolated between diamagnetism and the induction coil; they are, of course, naturally a part of the theory of electrical resistance, and have no near connection with the chapter preceding or following.

Great care has been bestowed on the illustration of the work. We know of no book on electricity so beautifully illustrated. Nor are the pictures merely pictures. They show well the details of apparatus; often, too, some leading dimensions are given when perspective does not admit of a scale. We would recommend this practice to all writers on science. It is a great help to the imagination to know how large a thing is, and better that this information should be upon the picture than in the text only.

In the construction of this book the freest use has been made of the scissors, whole pages being quotations. This is both wise and modest, for when the original works of the man who discovered and stated a fact are suitable for a treatise, there can be no use in paraphrasing them. Some of the chapters are excellent analyses of the several investigations which have been made into the subjects of which they treat. This is notably the case with the chapter on "Specific Inductive Capacity." When Mr. Gordon has occasion to prepare a new edition he will do well to expand where he is strongest, to omit as far as possible systematic exposition, but to make each chapter a history to which the reader may refer with confidence that he will there find a clear account of every original experiment, English or foreign, that has been tried in that department. The value of such a work would be inestimable.

STRATIGRAPHICAL GEOLOGY

Lethæa geognostica, oder Beschreibung und Abbilding der für die Gebirgs-Formationen bezeichnendsten Versteinerungen. Herausgegeben von einer Vereinigung von Paläontologen. I. Theil: *Lethæa palæozoica,* von Ferd. Roemer. Textband: Erste Lieferung. Pp. 324. (Stuttgart, 1880.)

THE study of fossils may be approached from two distinct points of view: we may regard them as furnishing us with additional illustrations of the diversities of form and structure in the animal and vegetable kingdoms, or we may study them as making their appearance in a certain definite order, and thus as characterising particular geological formations. The former is the point of view of the biologist, the latter that of the stratigraphical geologist. Palæontology, or the study of fossil forms, must necessarily be pursued as a branch of biology, for only by the study of their nearest recent analogues can we hope to interpret the fragmentary and often obscure relics of former inhabitants of the globe; but, on the other hand, the progress of systematic geology has been bound up with the study of fossils ever since it has been clearly recognised that strata can be identified by the organic remains which they contain.

German scientific literature is now being enriched by the publication of two very valuable works in which fossils are treated of, in the one case from the stand-point of the biologist, in the other from that of the stratigraphical geologist. The admirable treatise on palæontology by Zittel and Schimper gives an excellent account of the chief types of fossil plants in their relations to living forms, and the work of which we have placed the title at the head of the present article, promises to supply an equally important contribution to stratigraphical geology.

The title of "Lethæa Geognostica" was first employed by Bronn, who between the years 1835 and 1837 published a work under this name, in which he described all the

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